Forward dynamics of selected spatial one-dof linkage mechanisms with Dahl friction model in revolute joints

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Abstract

The dynamic analysis method of selected class of spatial one-dof linkage mechanisms, containing one spherical joint in their structure, is presented in the paper. As an example RSRRR mechanism built out of four revolute joints R and one spherical joint S is considered - Fig. 1. Friction was taken into account in the revolute joints, however spherical joint was treated as ideal one. In the procedure assumed the mechanism, in the form of a closed-loop kinematic chain, was divided into two open-loop chains, using a cut joint technique. In order to describe the motion of both chains joint coordinates, taken from robotics, were used [3]:

– for chain 1: $\mathbf{q}^{(1,1)} = \left[\psi^{(1,1)} \right]$,

– for chain 2: $\mathbf{q}^{(2,3)} = \left[\psi^{(2,1)} \quad \psi^{(2,2)} \quad \psi^{(2,3)} \right]^T$.

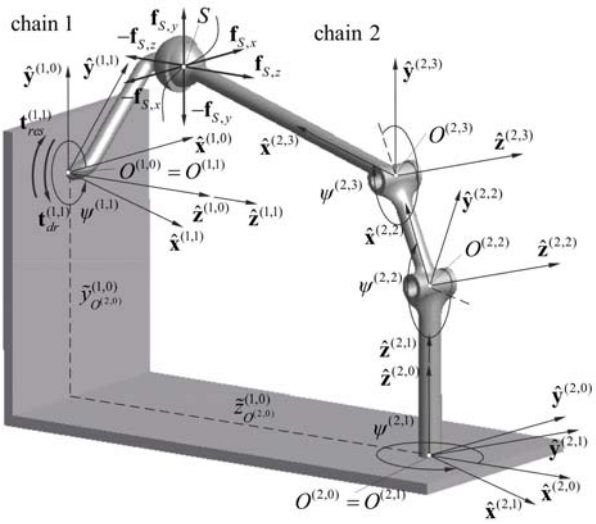

Figure 1: RSRRR one-dof linkage mechanism.

The equations of motion of the system were formulated using the formalism of Lagrange equations on basis of the algorithms given in the monograph [2]. These equations were solved using the Newmark method with an iterative procedure. In order to take friction in the revolute joints of the mechanism into account, joint forces and torques were calculated, in each integration step, using the Newton-Euler iterative algorithm [3]. The procedure used [1], including calculations within the scope of the static and dynamic analysis of the mechanism considered, was presented in Fig. 2.

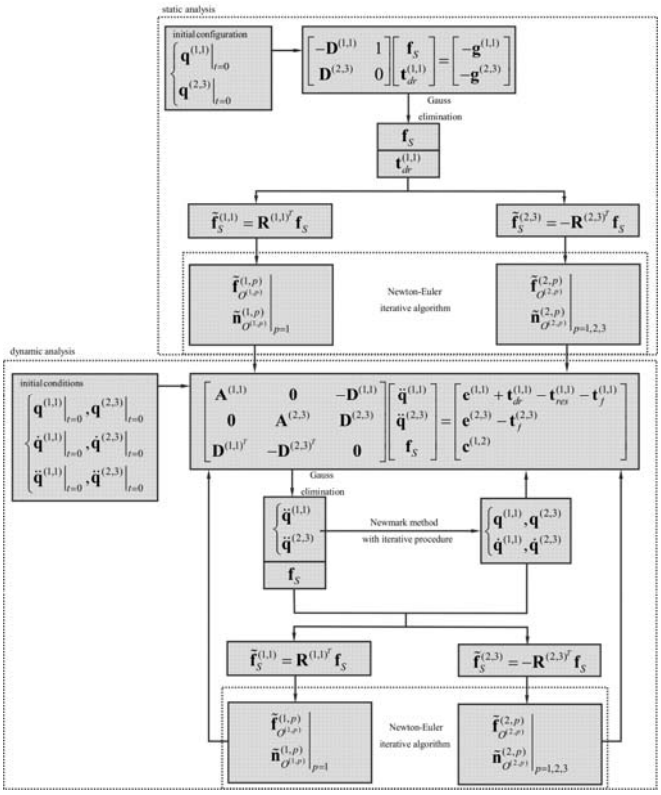

Figure 2: The algorithm of the analysis.

In order to calculate values of friction torques the model of the revolute joint was developed [1] - Fig. 3.

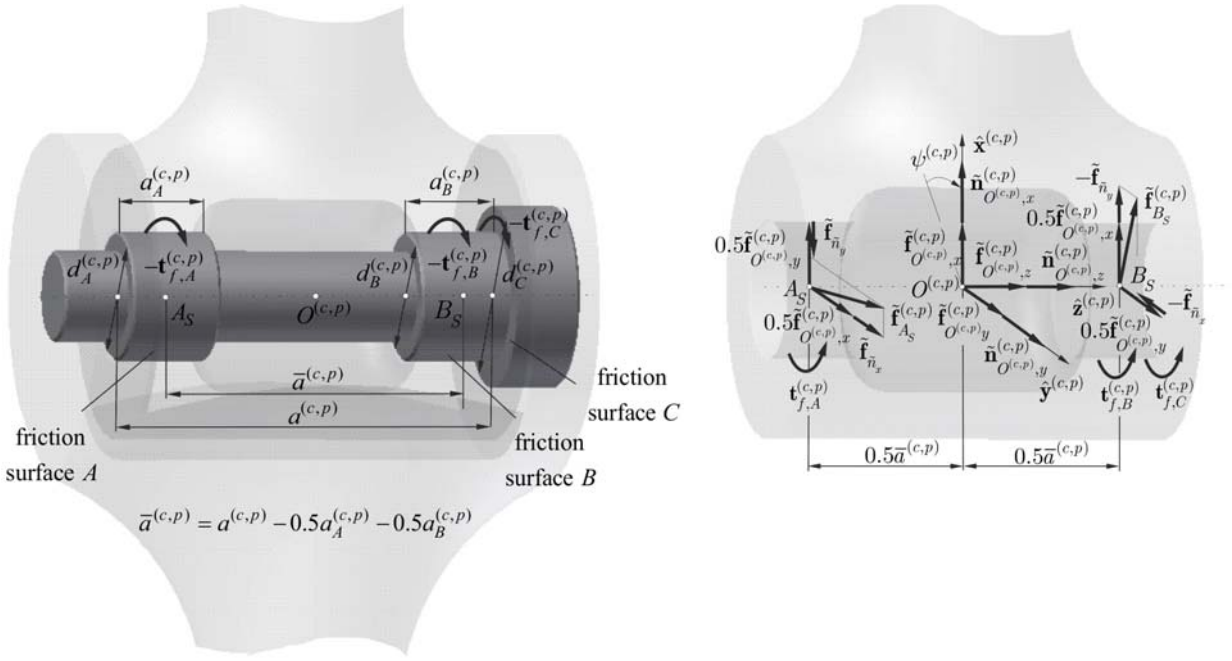

Figure 3: The model of the revolute joint.

The Dahl friction model [4] was used in order to consider friction in the revolute joints. This model is extension of the Coulomb friction model which allows to take into account the phenomenon of the presliding displacement in the joints at the start of the movement of the mechanism and at the velocity reversals of its links. It means that the courses of the kinetic friction coefficients as functions of relative angular displacements in these joints are described in the form of hysteresis loop - Fig. 4.

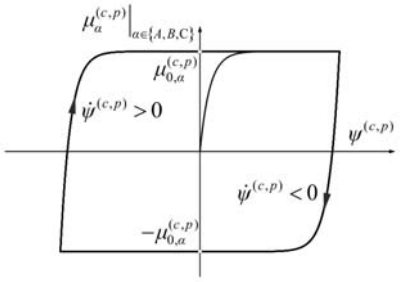

Figure 4: The Dahl friction model.

References

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